

# **Nutritional Ergogenic Agents: A Compendium for the Special Operations Command**



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# Ergogenic Agents

*Ergogenic agents* are substances or techniques purported to enhance physical or cognitive performance. These agents can be categorized as nutritional, pharmacologic, physiologic, or psychologic. In this pamphlet, we will specifically address what is currently known about various nutritional ergogenic agents. Such agents, marketed with claims of enhancing performance and/or building muscle mass, are purchased by individuals attempting to prolong physical performance, or become stronger, faster, and leaner. Few of these marketing claims are valid. Many claims sound convincing and scientific, however, they are often false or unproven. Our goal is to provide you with the most up-to-date scientific information regarding nutritional ergogenic agents.

The agents in this pamphlet are grouped according to the “expected” physiological effects. Information on each agent is presented regarding manufacturers’ claims, how it works, recommended dose, adverse effects, and comments. The recommended doses are taken from the literature and in all cases are doses to be taken by mouth. The groupings are as follows:

- ◆ Glycogen Sparers
- ◆ Intracellular Buffers
- ◆ Energy Enhancers
- ◆ Vitamins and Minerals
- ◆ Fat Burners/Lean Body Mass Enhancers
- ◆ Testosterone Enhancers
- ◆ Growth Hormone Releasers
- ◆ Miscellaneous

# Glycogen Sparers

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When we consume carbohydrates, the liver converts them into glucose. That glucose can then be delivered and used by the working muscle for energy production. Much of the glucose that is not used is converted to its stored form, glycogen, for use later. During prolonged endurance exercise, fatigue occurs when glycogen stores become depleted, therefore, if glycogen stores can be maintained, exercise can be prolonged. The following ergogenic agents have been professed to improve endurance performance by sparing glycogen stores.

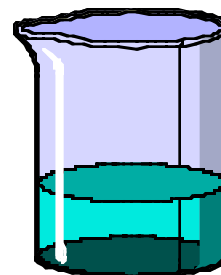
## ***Poly lactate Beverages***

### **Claims**

Delays onset of fatigue by maintaining blood glucose.

### **How It Works**

It doesn't seem right that a compound such as lactate, which is a by product of anaerobic muscle work, can be used as an ergogenic aid, but it may be possible. Ingesting carbohydrates during exercise maintains blood glucose which should allow work to continue for longer periods of time. In addition to blood glucose, muscle and liver glycogen stores are broken down to glucose to supply the working muscle with fuel during exercise.



Lactate, one of the breakdown products of glucose and muscle metabolism, can be reformed into glucose to be used later by exercising muscle. If blood glucose levels fall, then the liver must produce and release glucose, or exhaustion will occur. Since lactate can be taken up by both muscle and liver and made into glucose, supplementing with poly lactate may give the body the building blocks it needs to make more glucose; this action may delay the onset of fatigue. In addition, during very strenuous exercise, the heart actually derives most of its energy from circulating lactate.

### **Dose**

Prepare as directed on label; ingest 5 minutes prior to the event and then at 30 minute intervals during the event.

### **Adverse Effects**

None have been reported.

### **Comments**

Some benefits have been reported.

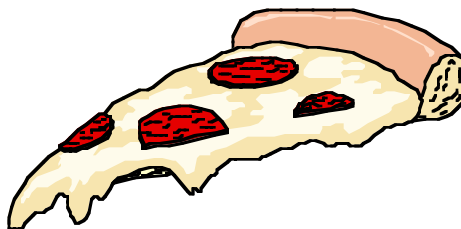
# Fat/Lipids

## Claims

Increases endurance performance.

## How It Works

Aerobically fit individuals have a greater capacity to store fat and utilize intramuscular fat reserves (triglycerides). Consumption of a high-fat diet results in enzymatic adaptations that enhance lipid oxidation (metabolism) during prolonged endurance exercise, while consumption of a high-carbohydrate diet reduces the capacity for free fatty acid oxidation and intramuscular fat storage.



During prolonged, *submaximal* endurance exercise free fatty acids become the main source of energy. Specifically, when a high-fat diet is consumed by an aerobically trained individual, triglyceride storage is enhanced and more free fatty acids are available for immediate energy production. This, in turn, spares glycogen (carbohydrate) stores. When fat is utilized and glycogen is spared, submaximal exercise duration can be prolonged.

## Dose

A dietary intake in which 40-70% of the calories are from fat. For example, if your energy intake were 3,000 kcal then 1,200 to 2,100 kcal would come from fat. This would equate to 130 to 230 grams of fat. A high fat diet must be in place for at least one to two weeks prior to the endurance event for any results.

## Adverse Effects

None have been reported, but high fat diets are not used routinely because of the potential cardiovascular concerns. Total cholesterol levels increase during the dietary period but return to normal post-diet. Should be used only for specific events as it is not designed for long term use.

## Comments

The reported benefits are questionable.

# Eicosanoid Controlled Diet

## Claims

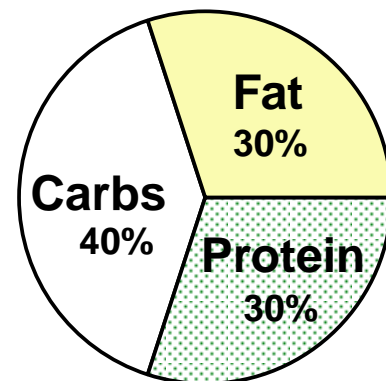
Purported to improve endurance performance.

## How It Works

The emphasis for this heavily marketed diet is maintaining the balance between the hormones, *insulin and glucagon*. These key hormones act in opposition, with insulin driving fuels into storage and glucagon retrieving fuels from storage. An ever responsive system must be ready to maintain the necessary balance between these two hormones. So

where do eicosanoids fit in? The promoters of this diet believe that eicosanoids are the ultimate regulators of glucagon and insulin. Eicosanoids are hormone-like substances controlled by the fat content of the diet, in particular, the intake of essential fatty acids. Essential fatty acids are “fats” that must come from the diet; they cannot be made in the body. There are various essential fatty acids, most of which can be transformed or converted into eicosanoids; however, the omega 6 fatty acids are considered the most important building blocks for eicosanoids. It gets even more confusing, because not all eicosanoids are equal: some are considered “good” and some “bad”, depending on their physiological effects. It is the ratio of “good” and “bad” eicosanoids that serves to regulate physiological functions.

Supposedly, the balance between “good” and “bad” eicosanoids can be controlled by the diet, specifically the dietary protein/ carbohydrate ratio. A high carbohydrate diet is believed to limit the production of “good” eicosanoids, in that high carbohydrate foods result in high levels of insulin. In contrast, when dietary intake of protein is higher relative to carbohydrate intake, the production of “good” eicosanoids is promoted and less insulin and more glucagon are released. Thus, it is the balance of protein to carbohydrate intake at every meal that induces a hormonal effect which can last for 4-6 hours; this balance between the hormones determines the glucagon to insulin ratio. The higher the protein intake the higher the glucagon to insulin ratio. Ultimately, an increased plasma glucagon/ insulin ratio helps to spare glycogen and forces a greater reliance on free fatty acids for energy production. Thus, the onset of fatigue is prolonged and performance is enhanced.



## Dose

The eicosanoid diet requires that every meal and snack provide 40% of the energy as carbohydrate, 30% as protein, and 30% as fat (the 40-30-30 diet). It is recommended that before starting such a diet that an estimate of lean body mass be calculated in order to determine an individual's optimal protein intake. After this has been obtained, the 40-30-30 diet can be created.

## Adverse Effects

None have been reported, but the potential for problems is great given the high levels of dietary protein.

## Comments

More research is needed. Eicosanoids appear to be affected markedly by diet, but the relationship between these hormones-like substances and performance has not been investigated.

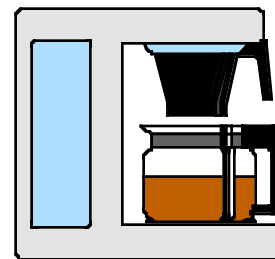
# Caffeine

## Claims

Delays fatigue, enhances performance and helps to mobilize fat.

## How It Works

Caffeine ingestion elevates free fatty acid (FFA) levels in your blood. It is believed that these FFAs are then used by the exercising muscle as fuel instead of muscle glycogen. In addition, use of caffeine may increase the use of fatty acids which are stored in the muscle as triglycerides. When fatty acids are used, then glycogen is spared, and the onset of fatigue is delayed. Exercise can be sustained longer because muscle glycogen stores are maintained as stored fuel to be used later in a workout.



Caffeine has also been shown to increase the affinity of the myofibrils (components of muscle fiber) for calcium. Calcium is necessary in muscle contraction and acts like a “spark” for muscle contraction. This increased affinity may allow for a more efficient muscle contractile mechanism.

The benefit from caffeine ingestion is specific to prolonged exercise at moderate intensity. Minimal physiological benefit has been reported when taken before high intensity, short term exercise. Caffeine can, however, “pump you up” mentally before a workout, which can lift your intensity level and thereby enhance performance.

## Dose

Typically, 6-13 mg/kg are taken one half to one hour prior to exercise; this equates to 420 mg to 910 mg of caffeine for a 154 pound person. Look at the caffeine levels in some common beverages; an 8 oz. cup of drip-prepared coffee typically provides up to 240 mg, depending on the brand of coffee. Individuals who consume “large” amounts of caffeine regularly (5-6 cups of coffee/day) do show tolerance or a blunted effect to the performance enhancing properties of this drug. So if you want to maximize the effects of caffeine, you need to have been off it for a few weeks. Also, a caffeine intake of over 7 mg/kg can produce urine levels close to or above the International Olympic Committee limits set for disqualification.

## Adverse Effects

Hyperexcitability of the central nervous system resulting in hyper alertness, increased irritability and increased heart rate. Urine output may also be increased. Delirium has been reported with ingestion of over 1 gram of caffeine. Possible death in doses of 18 grams. Upset stomach or gastrointestinal distress possible. Discourage use in people with ulcers or history of ulcers.



## Comments

Some benefits have been reported, but discontinue use if side effects (stomach pain, tremor) interfere with concentration or steadiness.

# Ginseng

## Claims

Reduces fatigue, improves memory, provides energy, and increases work capacity.

## How It Works

There are many different species of ginseng: Korean, Chinese, Japanese, American and Siberian. Many animal studies have shown reduction of fatigue, increased endurance, increased fat utilization with glycogen sparing, and anabolic activities such as protein synthesis. Most of the positive effects of ginseng in humans have been reported in the European literature: well-controlled studies remain to be undertaken.

## Dose

Ginseng is available in capsules and tablet forms and the usual daily dose ranges from 450 to 650 mg. Ginseng tea and other ginseng containing beverages are also available.

## Adverse Effects

Allergic reactions are possible. In some individuals, ginseng may cause excitation. However, unlike other ginseng species, Siberian ginseng (*eleutherococcus senticosus*) does not produce excitation or over stimulate individuals.

## Comments

Little to no benefit has been reported, but it is not harmful at the usual daily dose.

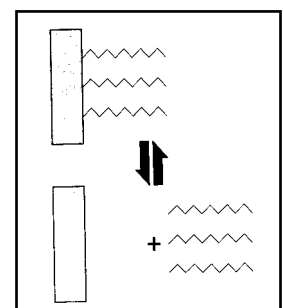
# Medium Chain Triglycerides

## Claims

Increases energy and reduces body fat.

## How It Works

Medium chain triglycerides (MCTs) consist of a glycerol backbone with three medium chain length fatty acids. Compared to long chain fatty acids (which are the components of most dietary fat), MCTs are more soluble and hence more rapidly absorbed. This means that they are more rapidly oxidized (burned as fuel) by your body and therefore, less goes into fat storage. Studies on rats support the claims. MCT



feedings increased energy expenditure and decreased the deposit of fat in these animals. There is, however, ambiguous information both supporting and discounting these effects in humans.

## Dose

Variable, but usual serving size is 16 to 32 grams daily prior to a work out. An 8 gram liquid form is available for use prior to exercise.

## Adverse Effects

None has been reported.

## Comments

Some benefits have been reported.

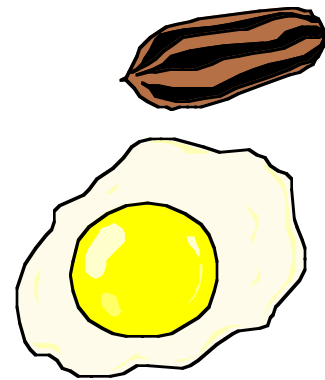
# Choline

## Claims

Delays fatigue, improves physical and mental performance, reduces fat.

## How It Works

Choline is a component of the cell membrane and is involved in fatty acid transport into the cell. The idea is that by supplementing with this agent you can increase the amount of fat being transported into the cell to be metabolized into energy.



Choline is also a precursor for the neurotransmitter, acetylcholine. Acetylcholine is present in certain brain regions associated with attention and memory and is also required for transmission of nerve to muscle impulses. Increases in plasma choline concentrations have been shown to increase acetylcholine release in the brain, however, research is inconclusive on how this affects mental performance.

Research on the impact of choline supplementation on physical performance is inconclusive because very few people have a choline deficiency. However, if you exercise sufficiently long and hard to reduce plasma choline concentrations, supplemental choline may help to maintain performance in long-distance, strenuous events, such as a 20 mile run or a two to three hour swim.

## Dose

Typically, 50 mg/kg of choline bitartrate is taken 30 minutes before endurance exercise. Foods rich in choline include meat, liver, eggs, and peanuts.

## Adverse Effects

No direct toxic effect, but use can lead to nausea, diarrhea and “fishy” body odor due to interaction with intestinal bacteria.

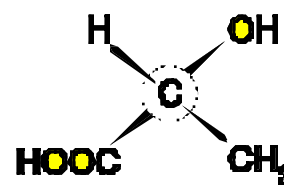
## Comments

Some benefits have been reported. Research is inconclusive, but it is not known to be harmful at above doses.

# Intracellular Buffers

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As exercise becomes more intense, muscle cells produce more lactic acid. When the muscles become too acidic, fatigue is the result. The body has a natural capacity to buffer muscle acidity, however, the body’s buffering system cannot maintain a non-acidic environment for an extended period of time. The following agents may help the body buffer muscle acidity, thus delaying the onset of fatigue.



Lactic Acid

## Phosphate Salts

### Claims

Delays onset of fatigue, improves oxygen transport to muscles, and improves maximal aerobic capacity.

### How It Works

Phosphorous is an essential (not produced by the body) mineral that may increase blood levels of an enzyme which improves transport of oxygen to exercising muscles. Ingesting phosphate salts is thought to increase blood levels of this enzyme which should lead to an improvement in oxygen transport to exercising muscles and maximal aerobic capacity. Phosphates are also components of a buffering system that can delay fatigue.

Pioneering work with phosphate as a beneficial supplement to soldiers began in World War I German field units who were fed meals high in phosphorous. A reduction in fatigue and improved psychomotor performance was observed at that time, but because of poor methodology, the results were called into question. Presently, research results are ambiguous with regard to performance.

### Dose

Approximately 1 gram, as a neutral-buffered phosphate, or 4 grams of tribasic sodium phosphate is taken 4 times daily for three to six days before a major event.

## **Adverse Effects**

Although no major disturbances have been reported, gastrointestinal intolerance is a likely possibility. Also, if soft drinks are routinely ingested, the phosphate content is high so that further phosphate loading would not be advised.

## **Comments**

Little benefit has been reported.

# ***Sodium Bicarbonate or Soda Loading***

## **Claims**

Enhances anaerobic performance, delays onset of fatigue.

## **How It Works**

May enhance performance in short duration (1 to 10 minutes) high intensity exercise, such as a sprint of 800 meters or less. Some benefit in performance during activities involving repeated episodes of high intensity exercise with minimal recovery time such as interval training.

Sodium bicarbonate is a natural buffer in your body that aids in neutralizing lactic acid produced during exercise. Lactic acid is thought to be partially responsible for exercise fatigue, and buffering it may delay fatigue. Lactic acid is also expelled from your body as carbon dioxide when you exhale during exercise. By ingesting or “loading” your body with sodium bicarbonate, you decrease the acidity (increase the pH) of your blood. You have now created an environment in your blood stream where the lactic acid produced during exercise can be more efficiently neutralized or buffered.

There is also evidence that increased blood bicarbonate levels allow lactic acid to be released from exercising muscles more efficiently. This allows the muscle to remain neutral and delay the fatigue caused by too much acid in the muscles.

## **Dose**

Usually 0.3 grams of sodium bicarbonate per Kg body weight is mixed with 1 liter of water and taken 1 to 2 hours before exercise.

## **Adverse Effects**

Some people have gastrointestinal symptoms, such as diarrhea or cramps, if they ingest bicarbonate without sufficient water. Serious medical problems can occur (called metabolic alkalosis or too little acid) if too much is ingested.

## Comments

Some benefit has been reported. It can be harmful if taken in large amounts. People with high blood pressure should not use bicarbonate.

# Aspartate Salts: Magnesium and Potassium Aspartate

## Claims

Improves aerobic capacity and may delay the onset of fatigue.

## How It Works

An increase in blood ammonia occurs during endurance exercise, which can have a negative effect on endurance exercise performance. Aspartate salts may increase work capacity by neutralizing the blood ammonia levels during prolonged exercise. It has also been suggested that aspartate salts may have an effect on glycogen resynthesis, phosphocreatine resynthesis, and glycogen sparing.

## Dose

Anywhere from 3 to 10 grams are taken over a 24 hour period.

## Adverse Effects

None have been reported at these doses.

## Comments

To date the research is inconclusive, and more studies will be needed to ascertain any benefits.

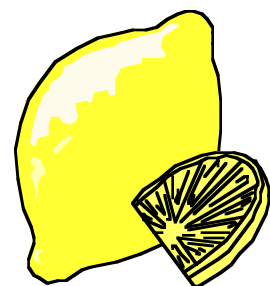
# Citrate

## Claims

Enhances performance by delaying the onset of fatigue.

## How It Works

The fatigue associated with high-intensity exercise may be a function of metabolite accumulation. One theory is that the increase in hydrogen ion concentration ( $H^+$ ), which occurs when lactic acid accumulates in muscle and blood, brings about fatigue. Citrate may increase the capacity of the blood to buffer  $H^+$  released from lactic acid; this could augment the body's natural buffering capacity and thereby delay the onset of fatigue.



## **Dose**

Usually 0.5 g/kg are taken as a single dose 60-90 minutes before an extended event.

## **Adverse Effects**

Gastrointestinal problems, nausea, and diarrhea have been reported.

## **Comments**

Some benefits have been reported, but be careful as problems can occur if taken in large dosages. If citrus fruits are eaten on a regular basis, dietary citrate will be high naturally.

# **Energy Enhancers**

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Muscles ultimately use adenosine tri-phosphate (ATP) for energy. ATP is produced when carbohydrates, fat, and/or protein enter a series of chemical reactions in the muscle cells of the body. The presence of oxygen at the muscle cell and the level of enzymes involved in the chemical reactions determine how much ATP is produced. Manufacturers claim that the following “energy enhancers” alter enzyme levels and/or improve delivery of oxygen to the cells; the result is an increase in the production of ATP, thus enhancing energy levels. Be careful with these!

## ***Inosine***

### **Claims**

An energy enhancer that may increase endurance and anaerobic/power events, such as strength training. Has been purported to facilitate recovery from exhaustive exercise.

### **How It Works**

Most of the claims are based on theoretical possibilities. For example, increasing cellular levels of inosine are thought to increase the production of adenosine which ultimately forms ATP-the energy substance used by cells. It has also been suggested that inosine may improve blood circulation to heart muscle and enhance release of oxygen in exercising muscles by elevating certain enzyme levels. In excess, however, inosine is not converted to energy precursors, but rather converted to uric acid by an enzyme that is a potent producer of free radicals. Build up of free radicals can increase oxidant stress.

Several studies have been conducted to investigate the ergogenic claims. No effect on endurance performance or power output, but rather a decreased time to fatigue during sprints on a bicycle have been noted. Thus, none of the claims have been substantiated.

## Dose

Doses range from 500 to 1000 mg 15 minutes prior to exercise on up to 6,000 mg/day for two to five days prior to an event.

## Adverse Effects

Oral administration in rats has shown intestinal lining degradation and possible free radical formation. Another potential problem is the exacerbation of gout by excess purine ingestion. Also, it may accelerate the onset of fatigue during anaerobic workouts.

## Comments

Dubious benefits are not worth the possible adverse effects.

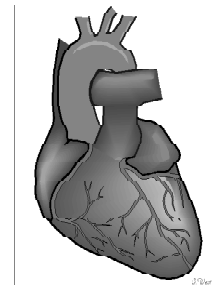
# Coenzyme Q<sub>10</sub> (CoQ<sub>10</sub>)

## Claims

Increases energy and cardiac performance.

## How It Works

Coenzyme Q<sub>10</sub> (CoQ<sub>10</sub>), a component of an enzyme found in the mitochondria ("powerhouse") of cells, is a potent anti-oxidant. Particularly high concentrations of this coenzyme are found in cardiac (heart) muscle. It is thought that by supplementing your diet with this enzyme, your heart's ability to respond to exercise will improve. This substance has been used with therapeutic success in patients with heart disease to increase their oxygen utilization and exercise performance. It also has been shown to increase submaximal and maximal exercise capacities in sedentary men.



Both positive results mentioned above were in people with damaged or non-athletic hearts. Your heart is athletic, so it should have already built up the enzymes it needs through exercise and have an excellent response to exercise, unlike a non-athletic or diseased heart which needs supports. That said, some studies have shown no benefit of CoQ<sub>10</sub> supplementation in athletic hearts.

## Dose

The usual dose is 1.0 mg three times a day. Foods rich in CoQ<sub>10</sub> include beef, eggs, and spinach.

## Adverse Effects

None have been reported.

## Comments

No benefits have been reported in athletes, but it does not appear to be harmful at the suggested doses.

# ***Desiccated Liver***

## **Claims**

Increases energy and performance.

## **How It Works**

Liver is a good reservoir of protein and many vitamins and minerals (B-complex and iron), which you may need if your exercise schedule is intense. If you already take a vitamin/mineral supplement, desiccated liver can offer minimal support to your overall dietary intake.

## **Dose**

3000 grams as a daily supplement.

## **Adverse Effects**

None have been reported.

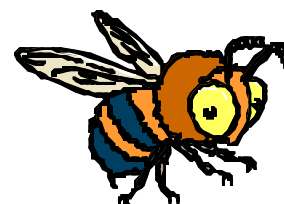
## **Comments**

No absolute benefits have been reported. Save your money as you probably get more than enough vitamins and minerals in your diet.

# ***Bee Pollen***

## **Claims**

Improves recovery after exercise, and serves as a general performance enhancer.



## **How It Works**

“Natural” food that contains numerous minerals, vitamins, and amino acids which may be beneficial during exercise recovery. Many studies report no beneficial effects on any physiologic response during exercise.

Some bee pollen contains certinin. Certinin is a plant growth factor claimed to stimulate human growth and muscle mass. Do not put much faith in what plant growth hormones can do for human bodies.

## **Dose**

The typical dose is 1.3 grams daily.

## **Adverse Effects**

Allergic reactions are possible.



## Comments

No benefits have been reported. Not harmful at suggested dose, but it can be a very expensive practice.

# Vitamins and Minerals

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Vitamin and mineral supplements are often used as ergogenic agents, but no proven ergogenic effects have been documented. If a balanced diet is eaten, an adequate supply of vitamins and minerals should be obtained. If a daily supplement is desired, try one and see if you feel a difference. In general, vitamins and minerals assist in the normal regulation of cellular metabolism. Below are examples of selected vitamins and minerals that have been taken by athletes with the intent of improving performance. This list is by no means exhaustive, but simply provides an example of what types of vitamins and minerals are commonly taken by athletes.



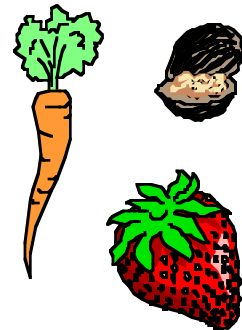
## ***Antioxidants; Vitamin E, Vitamin C***

### Claims

May accelerate recovery from muscle soreness and serve to minimize heat stress.

### How It Works

Free radicals, which are by-products of energy metabolism, have been implicated in exercise-induced muscle damage. Ingestion of antioxidants may reduce the inflammatory response that accompanies the 4-6 hour exercise recovery period by scavenging free radicals or by sparing/regenerating vitamins and minerals, especially in active people.



### Dose

Vitamin E: 400 mg/day beginning 3 weeks prior to performance.

Vitamin C: 500 to 1000 mg/day may reduce the incidence of upper respiratory tract infections after endurance events such as marathons and ultramarathons.

## **Adverse Effects**

None have been reported at these doses, but in some sensitive persons Vitamin C may cause intestinal distress or irritation.

## **Comment**

Supplementation would be necessary only if dietary intake is insufficient.

# ***Pantothenic Acid***

## **Claims**

Improves aerobic capacity and may be an “anti-stress” vitamin.

## **How It Works**

Pantothenic acid is physiologically active in the form of coenzyme A (co-A) which is involved in many metabolic pathways. Carbohydrates, fats, and proteins can be broken down into acetyl-CoA, which can enter an energy pathway where ATP is produced. Additionally, acetyl-CoA is a building block for the synthesis of fatty acids and some hormones.

Animals given pantothenic acid supplementation have an increased capacity to resist stress, whereas animals given pantothenic acid deficient diets develop fatigue and adrenal gland atrophy. The adrenal gland produces the stress hormone cortisol, hence, the “anti-stress” vitamin.

## **Dose**

The typical dose is 1-2 grams/day for 2 weeks.

## **Adverse Effects**

None have been reported.

## **Comments**

No benefits have been reported in humans. More research is needed.

# ***Niacin***

## **Claims**

No ergogenic claims. However it can have a negative impact on aerobic performance at high dosages.

## **How It Works**

Niacin can have a negative impact on aerobic performance by inhibiting the release of free fatty acids into the circulation, thus decreasing the proportion of energy derived from fatty acids. This will increase the reliance on carbohydrates. Niacin may also enhance the vasodilation of smooth muscle.

## **Dose**

The recommended dose is 6.6 mg per 1,000 kcal; 13 mg/2,000 kcal.

## **Adverse Effects**

It may have a negative impact on aerobic performance at high doses (3-9 grams/day) due to the increased reliance on carbohydrate metabolism. High doses can produce flushing and diarrhea.

## **Comments**

No positive ergogenic effect has been noted.

# ***Magnesium, Copper, Zinc***

## **Claims**

Beneficial effects on energy metabolism, and may serve to improve muscle strength and endurance.

## **How It Works**

Minerals are required for the maintenance of health and the development of optimal physiological function. As such, they are also important for optimal physical performance, particularly with respect to carbohydrate, fat, and protein metabolism. Minerals are also needed to maintain the structural integrity of essential molecules and work as cofactors to help a variety of enzymes function properly.

Some studies report suboptimal intakes of minerals, particularly among athletes who are trying to lose weight to meet standards for competition. If mineral intake is suboptimal, supplementation can improve overall health and performance. If on the other hand, adequate amounts of minerals are consumed on a regular basis, supplementation is not necessary.

## **Dose**

Magnesium = 300 to 350 mg/day; Copper = 2-3 mg/day; Zinc = 10-15 mg/day.

## **Adverse Effects**

None have been reported at the recommended dosages. At higher dosages gastrointestinal disturbances, mineral imbalances and toxicity may occur.

## Comments

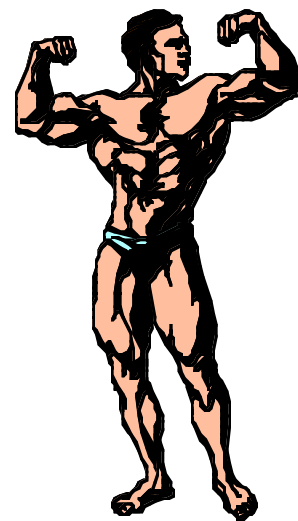
Supplementation is only necessary when dietary intake is insufficient. If insufficient levels are suspected, consult a nutritionist.

# Fat Burners/Lean Body Mass Enhancers

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Free fatty acids (FFA) are a significant energy source during endurance exercise. When the body increases its reliance on FFA metabolism, glycogen stores are spared and endurance exercise is prolonged.

Amino acids, the breakdown product of protein, can be used by the body as an energy source, or synthesized within the muscle. When there is an increase in amino acid synthesis and/or FFA metabolism, lean body mass is enhanced. The ergogenic agents in this group are used with the intent of increasing FFA metabolism ("burning fat") and/or amino acid uptake.



## ***L-Carnitine***

### Claims

"Fat burner", delays onset of fatigue. Improves aerobic exercise or endurance.

### How It Works

Carnitine is a vitamin-like compound that assists in transporting free fatty acids (FFAs) into the mitochondria ("powerhouse") of muscle cells for use as fuel. By supplementing with carnitine you could theoretically spare muscle glycogen and extend performance during endurance activity. There are numerous physiological reasons why carnitine supplementation may not be useful. One of the major reasons is that carnitine, in excess, is not efficiently absorbed into the human body. Only 1 to 2% of orally ingested carnitine actually ends up in muscle tissue. This is probably not enough to increase the FFA use.

Most studies have found no changes in fatty acid utilization or endurance performance with increased intake; however, there are reports of increased aerobic capacity in endurance athletes.

## Dose

The dose that has been used is 500 mg daily. Beef is a food rich in carnitine (average content is 50 mg/100 grams of edible portion.).

## Adverse Effects

Possible adverse effects include nausea, vomiting and stomach cramps. It is important to remember that the "L" isomer is the active form. If you ingest the "D" form you can actually create a carnitine deficiency in yourself. **READ THE LABELS!**

## Comments

Little to no benefit has been reported, but not harmful at recommended doses.

# Chromium Picolinate

## Claims

Increases muscle mass, "fat burner".

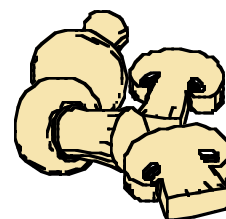
## How It Works

Chromium is an essential trace mineral that participates in glucose, amino acid, and free fatty acid uptake by cells via enhancing the action of insulin. Theoretically, adequate chromium levels in combination with insulin can delay the onset of fatigue during endurance exercise due to the sparing of glycogen stores and the increased utilization of free fatty acids as an energy source. In addition, amino acids (the building blocks of protein) can be transported into muscle cells for protein synthesis (building) especially during bouts of resistance training. This decreases muscle protein catabolism (breakdown) and allows for a more anabolic (building) state with an increase in lean body mass.

It is generally accepted that the dietary intake of chromium is sub-optimal for the general population and that exercise increases the chromium loss from the body. For this reason, it has been suggested that all athletes may need chromium supplementation. True effects remain to be shown but at the doses indicated below, it shouldn't hurt.

## Dose

As a dietary supplement: 50 to 200 µg (micrograms) / day. Foods rich in chromium include beer, brewer's yeast, oysters, mushrooms, meats, prunes, and whole grain cereals.



## **Adverse Effects**

Recommended dose may cause gastrointestinal intolerance. It was recently reported that prolonged use of chromium supplements at high doses (1 mg/day) may cause anemia, cognitive impairment, chromosome damage and/or interstitial nephritis.

## **Comments**

Benefits are questionable.

# ***Hydroxy-Methyl-Butyrate***

## **Claims**

Slows down the loss of muscle mass that occurs during intense training, and may improve strength.

## **How It Works**

Hydroxy-Methyl-Butyrate, or HMB, is a breakdown product of the essential amino acid, leucine, which is found in a variety of protein containing foods. It is theorized that increasing HMB in your diet would inhibit muscle protein breakdown, particularly leucine, and preserve fat-free muscle mass during intense training. Increases in muscle mass, and improvements in strength and physical performance would result. It has also been suggested that HMB supplementation may provide protection against the physiological effects of overtraining. Since HMB supplementation may preserve muscle protein, it may prevent decreases in muscle strength due to overtraining.

## **Dose**

The reported dose is approximately 1.5 to 3.0 grams per day.

## **Adverse Effects**

None have been reported at above dosages.

## **Comments**

More research is needed as animal and human studies have been inconclusive. One human study reports a decrease in protein breakdown and increased muscle function after three weeks of weight training.

# Testosterone Enhancers

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Testosterone, a male sex hormone synthesized by the body, can elicit anabolic (tissue building) and androgenic (masculinizing) effects. The basic idea behind “testosterone enhancing” agents is that testosterone builds muscle tissue, so “extra” testosterone can build muscle tissue further. Manufacturers claim that the following nutritional ergogenic agents can increase testosterone levels in the body. As you will see, these claims are not always accurate.

## ***Gamma- ( $\gamma$ ) Oryzanol and Ferulic Acid***

### **Claims**

Increases testosterone levels and lean body mass.

### **How It Works**

Chemically speaking, gamma oryzanol is actually two molecules in one. The largest part is the triterpenyl alcohol part, which is simply another name for sterol. Sterols are a group of compounds found throughout nature, with many vital biological functions. Some well known sterols are cholesterol and beta sitosterol. Many hormones such as testosterone, estrogen, progesterone, and cortisol, are derived from cholesterol, and can be thought of as modified sterols. The second half of each gamma oryzanol molecule is ferulic acid, a widespread plant compound.



Although this agent is believed to increase testosterone levels, the evidence most often cited to support claims of ergogenic effect is from infusion of this drug into cattle, not humans. The study reported slightly elevated growth hormone levels in cattle, but the effects of ferulic acid infusion on growth and lean body mass in the cattle were not measured. There is no scientific evidence that oryzanol will increase lean muscle mass or growth-related activity. In fact, animal studies suggest that injected oryzanol may decrease growth-promoting activity. No studies involving ingestion of these agents by humans have been reported, but because they are plant sterols, they should be poorly absorbed which probably means minimal effect on muscle mass.

More recently it has been reported that gamma-oryzanol/ferulic acid serves as a potent membrane antioxidant. The role of antioxidants in exercise performance has only recently been explored. Although further work is needed, oxidative damage to muscle cells may result in muscle fatigue, loss of endurance performance and delayed muscle soreness. Whether taking gamma-oryzanol/ferulic acid will minimize muscle oxidative damage remains to be shown

## Dose

Dietary intakes range widely depending on vegetable content of the diet; turnips are high in ferulic acid. Manufacturer product inserts are variable, but commonly 50 mg per day doses are recommended.

## Adverse Effects

Use of this drug is discouraged in people with lipid (fat) storage diseases. (You would know if you had such a condition).

## Comments

There is no proven benefit, and if derived from food no harmful effects would be noted. If manufactured products are taken, beware as the contents may not always be what is stated. Do not go over recommended doses.

# ***Glandulars: Testes, Pituitary, or Hypothalamus***

## Claims

Eating animal organs high in testosterone will elevate your testosterone levels. This “extra” testosterone will make you more anabolic (build up lean muscle mass).



## How It Works

Manufacturers want people to believe that taking glandulars (ground up animal organs, usually testes, pituitary, or hypothalamus) will elevate testosterone levels and increase muscle mass. This is simply not true because: (1) testes do not contain large amounts of testosterone; (2) digestive enzymes can destroy hormones such as those found in the hypothalamus and pituitary glands and render them inactive; and (3) taking testosterone can stop production of your own testosterone when levels are normal.

## Dose

They typically come as a dietary supplement mixed with protein/ carbohydrate powders. Do not exceed product information.

## Adverse Effects

Indigestion has been reported. In addition, if several hundred milligrams are ingested, the production of the body's own testosterone could shut down and blood testosterone levels may fall instead of increase.

## Comments

Their effectiveness is limited so these products are not worth the money.



# ***Smilax: Sarsaparilla, Sapogenins, Smilagenin, and Sitosterol***

## **Claims**

Increases muscle mass and lean body weight by increasing testosterone levels; a testosterone precursor. More recent claims include promoting workout recovery and tissue repair by acting as an anti-inflammatory agent.



## **How It Works**

Smilax products are derived from a variety of plants (climbing or shrubby) living in the warm climates of both the northern and southern hemispheres. Derivatives of these shrubs were initially used to treat virility and symptoms of menopause. The dried root of one species is used to make sarsaparilla, which is an approved flavoring agent in food. The claims made by manufactures are that these products are plant-derived, natural, growth-promoting hormones. Smilax plants contain sapogenins, sitosterol, stigmasterol, and sarsapogenin, which are structurally related to the hormones, testosterone and estrogen. It is thought that because these substances can be converted to steroids (in the laboratory under heat and pressure) that the same conversion will take place in your body. However, this is not necessarily true as humans may lack the enzymes necessary to convert plant sterols into testosterone.

Many athletes and bodybuilders have taken these products with subjective reports of increases in body weight, lean body mass, strength and aggression, and accelerated recovery from workouts and tissue repair. However, no controlled laboratory studies have yet been conducted.

## **Dose**

The typical product is either sub-lingual or capsular, and is used prior to a workout and/or before bedtime. A Smilax spray is also available and appears to be popular among strength athletes because it eliminates the problem of messy drops; the dose for the spray is 500 mg per day.

## **Adverse Effects**

Light headedness and some increased aggressive behavior have been reported. Liver damage has been reported in animals that graze on grasses with a high sapogenin content. No reported human toxicity. Be informed that some suspensions of this agent are in 18% alcohol. READ THE LABEL!

## **Comments**

Minimal benefit has been reported in the literature. All claims are based on manufacturer's subjective questioning of athletes.

# **Yohimbine**

## **Claims**

Aphrodisiac, testosterone enhancer, and a prescription agent to cure male impotence.

## **How It Works**

Yohimbine is an herbal extract derived from the bark of the African tree, *Pausinystalia yohimbe*, and has been used for centuries as an aphrodisiac and a cure for male impotence. There are numerous studies which both support and deny the claims, but it is important to realize that positive results are not because of increased testosterone levels. Yohimbine has very specific actions in the body and is one of the only approved medicines for impotence. It is also used clinically for various conditions beyond the scope of this pamphlet.

Recently, yohimbe has also become a popular fat-loss supplement for both men and women. Yohimbe may work by inhibiting the accumulation of excess fat in the lower body regions of the buttocks, hips, and legs.

## **Dose**

The dose most often noted is 250 mg two to three times daily with food.

## **Adverse Effects**

Side effects often make yohimbine very difficult to utilize. Yohimbine can induce anxiety, panic attacks, and hallucinations in some individuals. Other side effects include elevations in blood pressure, and heart rate, dizziness, headache, and skin flushing. Yohimbine should not be used in individuals with psychological disturbances. A small percentage of males experience anxiety, dizziness, nausea, chills, headaches, and vomiting. In high doses generalized depression has also been reported.

## **Comments**

Because it has known physiologic actions unrelated to performance, it should not be used to increase testosterone or lean muscle mass. Discontinue if side effects become a problem. There are no commercial sources of yohimbe bark that are available to physicians or in health food stores which actually state the level of yohimbine per dosage. Without knowing the content of yohimbine, it is virtually impossible to prescribe an effective and consistent dosage. Because of the variability in yohimbine content of yohimbe bark, the FDA classifies yohimbe as an unsafe herb.

# **Boron**

## **Claims**

Increases testosterone levels.

## How It Works

Boron is an ultra-trace mineral thought to regulate the hormone which controls the metabolism of calcium, phosphorous, and magnesium. Claims of increased testosterone levels in humans from boron use originated from a 1991 study involving post-menopausal women. Subsequent studies involving male body builders supplementing with boron revealed mixed results: some saw no increase in testosterone as compared to placebo whereas one study did report an increase.

## Dose

The doses used have ranged from 1 to 10 mg daily. Foods high in boron include raisins, almonds, apples, pears, soy meal and tomatoes.

## Adverse Effects

Acute toxicity from supplement use can be a problem. The symptoms include nausea, vomiting, diarrhea, skin rash, and lethargy.

## Comments

Little or no proven benefit.

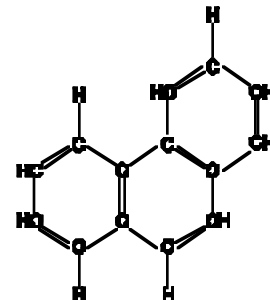
# DHEA/Dehydroepiandrosterone

## Claims

Slows down aging, burns fat and builds muscle mass, boosts libido, strengthens the immune system, wards off heart disease, non-insulin-dependent diabetes, Alzheimer's and Parkinson's diseases.

## How It Works

Dehydroepiandrosterone, or DHEA, is a substance produced naturally by the human adrenal gland. It is a universal starting material for different growth-promoting and sex-specific hormones, such as testosterone and estrogen. Its cellular and molecular mechanisms of action remain unknown, but it is being widely marketed as an anti-aging and fountain of youth cure-all. Shortly after birth, levels of DHEA in people drop then begin to rise dramatically during puberty. DHEA levels peak in early adulthood, after which levels decrease continuously with age. Preliminary studies in elderly people show that supplemental DHEA may help improve mood, boost the immune system, increase muscle mass, and enhance cognitive function.



## Dose

The recommended dose for women is 25 mg/day and the dose for men is 50 to 100 mg/day in pill form. Wild or Mexican yam is not a reliable source of DHEA.

## Adverse Effects

High doses may cause virilization (baldness, body hair growth, voice deepening) in women and breast growth in men. May also cause oily skin and acne. High levels have been associated with increased risk for ovarian, prostate, and other types of cancer. There is speculation that in individuals below 30 years of age, supplemental DHEA may suppress their own body's production of DHEA.

## Comments

Usage is widespread. More research is needed to determine whether supplemental DHEA is indeed safe, and has a positive effect on performance.

# Growth Hormone Releasers

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Human growth hormone, produced by the pituitary gland in the brain, is responsible for facilitating muscle, bone and cartilage growth. It also has an affect on energy metabolism: carbohydrate use by muscle tissue is restricted by growth hormone, whereas the mobilization of free fatty acids from fat stores is promoted. A variety of factors can affect growth hormone release, such as sleep, dietary patterns, exercise, and stress. Exercise is known to increase the release of growth hormone in proportion to the intensity, but the increases is only for a short period of time. The growth hormone response to exercise is also affected by body composition, with persons with more body fat having a smaller response than a lean person at the same relative work intensity. Because of the unique affect of growth hormone on muscle mass and strength, any agent that can stimulate its release has been marketed. The following agents have been claimed to increase the secretion of growth hormone from the pituitary gland.

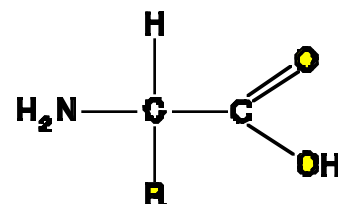
## *Arginine, Lysine, and Ornithine*

### Claims

Stimulates growth hormone release.

### How It Works

It is well documented that an arginine infusion will produce a reliable increase in serum growth hormone in adults. However, it is unwise to conclude that the same results are possible (and reliable) with oral supplementation. For example, one study revealed that an increase in growth hormone was achieved when arginine (1200 mg) and lysine



(1200 mg) were simultaneously taken orally. In the same study, however, ingestion of arginine alone at double the dose (2400 mg) produced a decrease in growth hormone. Still other studies reveal no ergogenic effect of arginine when compared to placebo.

Similar ambiguous results are found with oral ornithine ingestion. In one study, however, everyone taking oral ornithine developed stomach cramps and diarrhea, which alone can cause an unexpected increase in plasma levels of growth hormone.

Many factors such as exercise lead to growth hormone release. For example, resistive weight training can lead to growth hormone release. It is debatable whether amino acid supplements provide greater anabolic effect than weight training alone.

## **Dose**

Variable. Arginine - 500 mg one hour before meals and/or before workout. Ornithine - 500 mg a day or 250 mg one to three times a day. These items are sold separately or in combinations with varying amounts of each amino acid.

## **Adverse Effects**

Gastrointestinal intolerance is a major concern. However, the potential for amino acid imbalance and a decrease in growth hormone levels needs to be recognized.

## **Comments**

No benefits have been reported for Ornithine. Some benefit has been reported for Arginine and Lysine.

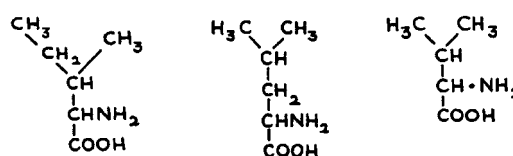
## **Free Amino Acids versus Intact Proteins**

Claims have been made that free amino acids are absorbed or utilized more efficiently than intact proteins (amino acids bound together as proteins or strings of amino acids). A common reference to these claims is a study involving four hospitalized patients who received either free amino acids or intact proteins. Three of the four patients had malabsorption conditions, and their gastrointestinal tracts were diseased, and free amino acids were more effectively absorbed by the intestines. However, the results reported may not apply to a healthy intestinal tract. Thus, it is difficult to use the information from that study to make claims about athletes. The general consensus is that in a normally functioning digestive system, there is little reason to purchase amino acids in free form, rather than ingest them as dietary proteins in regular foods.

# Branched Chain Amino Acids: Leucine, Isoleucine, Valine

## Claims

These particular amino acids are believed to: serve as anabolic and growth hormone stimulators and enhance muscular endurance, strength, and aerobic capacity, particularly during heat stress.



## How It Works

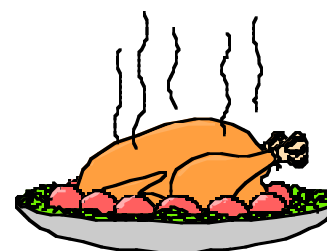
It is well known that aerobic exercise increases protein breakdown. Although after exercise the protein is “rebuilt”, the protein breakdown could be counter-productive if your goal is to increase lean body mass. Branched Chain Amino Acids (BCAAs) are special types of amino acids that are selectively taken up by muscle tissue during exercise. These amino acids appear to be used as fuel by the exercising muscle, and having “extra” BCAA in the blood may allow more of them to be utilized for energy. This process may spare the other amino acids present in muscle protein. Thus, the presence of BCAAs in blood may slow down or minimize the breakdown of muscle protein.

BCAAs may also be effective in delaying the onset of fatigue and making athletes “feel” better after exercise. During prolonged exercise there is an increase in the plasma concentration of a certain amino acid, tryptophan. Tryptophan can enter the brain where it is converted into a substance known as serotonin; increased levels of serotonin in the brain have been linked to lethargy in humans and exercise-associated fatigue in the rat. Thus, high blood levels of tryptophan may contribute to “mental fatigue” during exercise. It has been proposed that BCAAs can block the entry of tryptophan into the brain, and thereby delay the feelings of fatigue. Recent work indicated that administration of BCAA (5 ml/kg body weight with 5.9 grams of BCAA per liter (L) water in the proportions: 54% leucine, 19% isoleucine, and 27% valine) extended moderate exercise performance in the heat.

Lastly, whereas an infusion of leucine has been shown to release growth hormone in humans, infusions of isoleucine and valine have had minimal effects on growth hormone release.

## Dose

There are various products with different amounts of BCAA in them. For example: Leucine 800 mg daily. Isoleucine 300 mg. Valine 200 mg. These are usually consumed prior to exercise. Foods rich in BCAAs include turkey, chicken, other meats, and navy beans.



## Adverse Effects

Gastrointestinal problems, such as diarrhea and stomach/intestinal cramping, have been reported.

## Comments

Some benefits have been reported, especially when exercising in the heat.

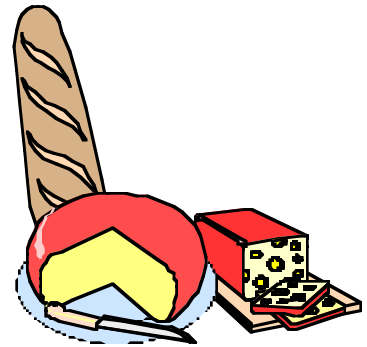
# Dibencozide or Cobamamide

## Claims

A growth promoting aid.

## How It Works

Promoters of this agent stress that dibencozide is the primary active and storage form of Vitamin B<sub>12</sub> in the body. Vitamin B<sub>12</sub> serves a role in the activation of various amino acids during protein synthesis and in the breakdown of certain amino acids. Vitamin B<sub>12</sub> is also important in building of muscle tissue. As such, this vitamin is promoted as a non-hormonal, natural, growth promoting agent, which is effective in helping to build strong muscles.



The effects of dibencozide, cobamamide, and other co-enzyme forms of Vitamin B<sub>12</sub> have been compared to the effects of anabolic (growth-promoting) steroids. The study that is often referenced involved children with growth deficiencies and other medical conditions and their subsequent positive response to the use of B<sub>12</sub>. It is difficult to infer, based on such a study, whether there are any ergogenic effects in athletes. One study in young men compared 1 mg of cyanocobalamin (the commercially available form of B<sub>12</sub>) versus placebo for six weeks, and found no differences in maximum aerobic capacity, hand-grip strength, ability to do pull-ups, or leg-lift strength.

## Dose

A typical dose is 500 µg (microgram) daily in tablet form. Unless there is a problem with absorption of Vitamin B<sub>12</sub>, dietary intake should be adequate; animal products, cheese, fish and milk are all good source of this vitamin. Vegetarians may need a supplement; if in doubt, contact a nutritionist or physician.

## Adverse Effects

No adverse effects have been reported at above dose.

## Comments

Little or no proven benefit, but no harmful effects have been noted at the recommended dose.

# Miscellaneous Agents

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The various claims of many agents cannot appropriately be grouped under any of the other headings. These agents have been classified as miscellaneous agents and descriptions are provided below.

## ***Octacosanol-Wheat Germ Oil***

### **Claims**

Improves endurance capacity.

### **How It Works**

The results suggesting that octacosanol (the active ingredient in wheat germ oil) improves performance in humans are, at best, ambiguous. In fact, the general consensus is that it is not beneficial in aerobic exercise.



Octacosanol has been shown to improve conditioned reflexes, as measured by reaction time tests. One possible mechanism could be that it helps stabilize nerve cell membranes making nerve transmission more efficient. Whether it would be useful during sleep deprivation, cold exposure, or other conditions where reaction time is important has not yet been answered.

### **Dose**

The range of the dose is wide: 100 to 6,000 mg daily. Results should not be expected for about 4 to 6 weeks.

### **Adverse Effects**

Allergic reactions are possible.

### **Comments**

Some benefit has been reported, but may need to try to see if desired results are obtained.

## ***Glycerol***

### **Claims**

Improves endurance performance by optimizing hydration status, especially under exercise-heat stress conditions.



## How It Works

During endurance exercise, the increase in skin blood flow and perspiration helps to regulate the body's core temperature. In response to these adaptations, plasma volume decreases, which can compromise hydration status/ fluid balance. After glycerol is ingested and evenly distributed throughout the body, total body water, plasma volume, and plasma osmolality (number of particles) increase, whereas urine volume decreases. Thus, glycerol ingestion produces a state of "hyperhydration". It has been hypothesized that the physiologic changes associated with glycerol ingestion should minimize the stress imposed by exercising in the heat.

## Dose

The usual dose of glycerol is 1.0 to 1.5 grams in 25 mL water/kg lean body weight.

## Adverse Effects

Cerebral (brain) and intraocular (eye) dehydration, nausea, vomiting, and diarrhea may occur.

## Comments

Most studies show that hyperhydration with glycerol provides no advantage over maintaining hydration, even under conditions of heat stress.

# Omega-3 Fatty Acids

## Claims

Improves aerobic capacity.

## How It Works

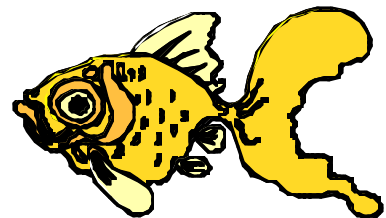
Omega-3 fatty acids are members of a family of fatty acids with characteristic structure. Linolenic acid is an omega-3 fatty acid, and is required in the body for normal growth and development. Two other omega-3 fatty acids are docosahexanoic and eicosapentanoic acid; these fatty acids are also known as fish oil fatty acids. Omega-3 fatty acids may be important in reducing the risk of diseases, such as heart disease, high blood pressure, arthritis, and cancer. No beneficial effects of omega-3 fatty acids on performance has been shown, but they can influence eicosanoid formation, which may have an impact on performance.

## Dose

The typical dose is 4 grams/day for 10 weeks. Dietary sources include fish, nuts, seeds, soybeans, and vegetable oils (except coconut and palm oils).

## Adverse Effects

None have been reported at these doses.



## Comments

To date no ergogenic effects have been reported, but more research is required.

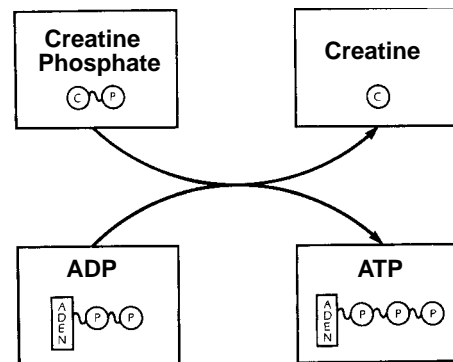
# Creatine

## Claims

Increases availability of muscle adenosine triphosphate (ATP) during sprinting and explosive high intensity exercise. Has also been reported to increase total body weight and / or lean muscle mass when taken for extended periods.

## How It Works

The work our muscles do is fueled by ATP. The body's muscle store of ATP is very small and is quickly used up during muscle contraction by being "dephosphorylated" to adenosine di-phosphate (ADP). In order for the muscle to continue contracting during short duration, high intensity exercise, ATP must be regenerated. Creatine, in its phosphorylated form, creatine phosphate or phosphocreatine (PCr), helps to regenerate the ATP from ADP, and thereby sustain the ATP needed by the muscle for short periods of time. PCr depletion in the muscle during short-duration high-intensity exercise is associated with lower ATP / ADP ratios in muscle and the onset of muscle fatigue.



Supplementation with creatine prior to short-duration high-intensity exercise may allow the muscle to store extra PCr; these extra stores should help maintain high muscle ATP / ADP ratios so that maximal physical effort can be sustained for a longer period of time. A number of studies on creatine loading have been done: some show an improvement in high intensity exercise performance, and others do not. Particularly, creatine does not appear to improve sprint performance in swimmers or bikers. However, supplementing with 20 grams of creatine a day for 6 days has been shown to increase muscle creatine concentration from 10 to 20%; when supplementation is stopped, normal muscle levels of creatine were regained within 30 days. Only a few studies have looked at prolonged usage of creatine. Supplementation for 28 days (15.75 grams creatine / day in combination with a glucose electrolyte supplement) resulted in significant gains in lean body mass, sprint performance, and strength.

## Dose

The dose most frequently reported is 5 x 4 grams / day consumed for five to six days prior to working out. However, the benefits on prolonged supplementation (28 days) is being investigated. Foods rich in creatine include meat and fish.

## Adverse Effects

No serious side effects have been reported with short term use, however muscle cramping has been mentioned. In all cases, caution is encouraged with prolonged (greater than four weeks) high doses.

## Comments

Some benefits have been reported during high-intensity exercise. It is important to note that any improvement in performance by creatine during short term strenuous exercise can be overcome by caffeine intake.

# Tyrosine

## Claims

Reverses cold induced working memory deficit. Decreased stress-induced cognitive performance degradation and may maintain performance under conditions of distraction.

## How It Works

Tyrosine is an amino acid required for the manufacture of the neurotransmitters: norepinephrine, epinephrine, and dopamine. Various forms of stress (environmental, fatigue, and decreased sleep) can decrease brain levels of norepinephrine and result in performance degradation. Supplementation with tyrosine can increase blood and brain levels of tyrosine which may promote increased production of brain norepinephrine. Increased levels of norepinephrine could improve attentional focus and protect against cognitive performance decrement. This would be useful in cold or stressful environments to maintain mental alertness.

## Dose

The usual dose of L-tyrosine is 150 mg/kg body weight, 1 to 2 hours prior to the designated exposure.

## Adverse Effects

None have been noted.

## Comments

Clear benefits have been documented during SEAL cold weather operations and in multitasking cognitive events. However, more work will be needed to extend the findings.

# Glutamine

## Claims

Promotes muscle growth. Helps prevent fatigue, overtraining syndrome, and possible immune dysfunctions.

## How It Works

Glutamine is the most abundant amino acid in the body with 60% stored in the muscles. It is used as fuel for other cells, especially cells of the immune system. It is also important in neutralizing ammonium ions in the body which are toxic to cells. When the body is under stress, like a strenuous workout, various organs increase their use of glutamine. Strenuous exercise also results in elevated plasma levels of lactic acid and ammonia, which causes levels of glutamine in the blood to drop. When glutamine levels drop, the muscles start to release its own glutamine stores into the blood, so that after exercise, muscle glutamine can be low. If a person trains often enough, glutamine stores in the muscle may not be adequately restocked, and if this happens too often, a person may become overtrained and fatigued.

Glutamine supplementation increases blood levels of glutamine so the muscles do not have to release it. This may help delay the feelings of fatigue and overtraining syndrome. With enough glutamine in the blood, the immune system will not lack sufficient fuel to keep it working properly.

## Dose

The dose most often quoted is 500 - 1,000 mg in the free amino acid form, twice daily, or right before exercising. A high protein diet will also increase the body's store of glutamine.

## Adverse Effects

None have been reported, however, a dose higher than 2 grams/day may negate any benefits.

## Comments

This agent has not been shown to enhance performance, but may help prevent performance decrements and fatigue.

# ***Glucosamine/Chondroitin Sulphate***

## Claims

Speeds up recovery from musculoskeletal injuries. May protect against knee problems and stress fractures.

## How It Works

Glucosamine is an essential component of joint cartilage and connective tissue. Additionally, this compound has anti-inflammatory properties which may be useful in treating overuse injuries such as tendinitis.

## **Dose**

The doses used range from 250 to 500 mg with meals, up to three times daily.

## **Adverse Effects**

No adverse effects have been reported.

## **Comments**

Has the potential for preventing and/or treating musculoskeletal injuries, but your physician should be contacted first about any injury.